# Data and Analysis Methods for Metropolitan-Level Environmental Justice Assessment

Charles L. Purvis
Senior Transportation Planner/Analyst
Metropolitan Transportation Commission
101 Eighth Street
Oakland, California 94607-4700
(510) 464-7731
e-mail: cpurvis@mtc.ca.gov

November 2000

**ABSTRACT**

This paper examines data sources and analytical methods available to metropolitan transportation planners for use in technical activities related to environmental justice and Title VI discrimination analyses. The focus is on data and methods employed by the metropolitan planning organization (MPO) for the San Francisco Bay Area. An initial technical activity is the preparation of a geographic and demographic profile of the region with respect to low-income, minority, elderly and disabled persons. Difficulties associated with long-range forecasting of these variables at the small area (county) and very small area (travel analysis zones, neighborhoods) is discussed. Citizens advisory groups are needed to provide early guidance to this technical activity, and to appreciate the uncertainties associated with the data and methods. The paper outlines transportation analysis procedures to analyze changes in accessibility between alternatives in the long-range regional transportation plan. These methods map out changes in accessibility to evaluate impacts on transportation "disadvantaged" versus "not-disadvantaged" neighborhoods. The paper concludes with a discussion of future data sources, including Census 2000 and the American Community Survey (ACS). The ACS data, in particular, may prove highly beneficial in describing changing socio-economic patterns within a metropolitan area.

KEYWORDS: environmental justice, socio-economic, data, census, projections, forecasting, discrimination

**INTRODUCTION:  CONTEXT FOR ENVIRONMENTAL JUSTICE ASSESSMENT**

The purpose of this paper is to explore the data availability and analysis methods to support environmental justice and U.S. Civil Rights Act Title VI analysis for metropolitan level program analysis. The focus of this paper is not on public involvement issues regarding environmental justice and Title VI, though the issue of working with citizens advisory groups in improving the technical planning analysis is discussed. The geographic focus for this study is the nine-county San Francisco Bay Area in California, though the data and methods are perhaps transferable to other metropolitan areas and states. The emphasis here is on program-level analysis (e.g., update of long-range regional transportation plans, transportation improvement programs) rather than project-level analysis (e.g., highway and transit expansion projects.)

An excellent discussion on the history of the environmental justice movement and principles of environmental justice is the law review article by Calloway and Ferguson (1). The authors trace the roots of the environmental justice movement to a 1987 study by Dr. Benjamin Chavis and the United Church of Christ's Commission for Racial Justice. The Chavis study evaluated the location of hazardous waste facilities in the United States with respect to the location of communities of people of color. Chavis coined the term "environmental racism" which evolved into principles of "environmental justice" in the late 1980s and early 1990s. The reader should also refer to the resource paper by Kennedy (2) for an appreciation of environmental justice issues related to the transportation sector.

The U.S. federal government formalized a national environmental justice policy in 1994 (3), followed by US Department of Transportation policies in 1997 (4), and the FHWA Order on Environmental Justice, December 1998 (5).  Further guidance on implementing environmental justice and Title VI requirements for metropolitan planning activities was prepared by the US Department of Transportation in October 1999 (6, 7). In particular, the FHWA/FTA memorandum of 10/7/99 (6) discusses Title VI issues for MPO planning

certification reviews. The FTA notice on "Fiscal Year 2000 Apportionments, Allocations and Program Information" (7) discusses "transportation equity and public involvement" as a federal "planning emphasis area" for FY 2000.

The most recent turn of events are the proposed metropolitan and statewide planning regulations released May 2000 (8). With respect to transportation plan development, the proposed regulations require the development of a "discrimination assessment" which needs to be complemented by a) consideration of public comments; b) mitigation efforts to address adverse impacts; and c) documentation for public review. Components of the metropolitan discrimination assessment would include: a) a geographic and demographic profile of the metropolitan planning area, including identification of low-income, minority, elderly and persons with disabilities populations; b) a description of transportation services available and planned for these population segments; and c) description of disproportionately high and adverse environmental impacts, or a reduction in benefits to these population segments. Essentially these regulations are to ensure consistency of metropolitan plan development with federal discrimination laws, including the Age Discrimination Act of 1974, the Rehabilitation Act of 1973, the Disabilities Act of 1978, and the Americans with Disabilities Act of 1990.

Other ongoing activities to research data and methods in support of environmental justice analysis include NCHRP Project 8-36, Task #11 "Technical Methods to Support Analysis of Environmental Justice Issues" and NCHRP Project 8-41 "Development of Technical Methods for Environmental Justice Analyses." Products from these NCHRP studies should be available between 2001 and 2003. Other training and technical assistance activities are underway at the US Department of Transportation (9).

The balance of this paper discusses past and proposed activities to accomplish the environmental justice objectives as expressed in federal guidance. These activities are based on understanding of the strengths and weaknesses of federal, state and local data and analysis methods. The next section discusses data and methods to prepare a regional demographic profile. The third section of this paper reports on transportation equity

analysis procedures used in the most recent update of the Bay Area's regional transportation plan. Other options and opportunities for improvement are suggested. The final section discusses new and emerging data sources, including Census 2000 and the American Community Survey (ACS). In particular, the American Community Survey may provide regional planners and citizens with data on small area changes in socio-economic characteristics throughout the decade, rather than once every ten years as with existing census "long form" data.

## DATA AND METHODS FOR PREPARING A REGIONAL DEMOGRAPHIC PROFILE

The challenge for the metropolitan transportation planner is to creatively assemble past, present and future (projected) data related to the detailed socio-economic characteristics of their planning area. The first problem is knowing if the data exists and how to acquire it. The second challenge is the geographic resolution of the data, and how to display or map the data. The third problem relates to how to express the statistical uncertainty associated with old, current and projected data. A fourth issue relates to using this information with citizens advisory groups as a foundation for analyzing the environmental impacts of the proposed transportation plan.

A truism with respect to data is that data about the past is more accurate than data about the future. Old data from the 1990 Census is quite valuable in depicting the geographical distribution of low-income, minority, elderly and disabled persons – as of 1990! Current estimates of population by these market segments is hard-to-impossible to come by, and future year projections of these attributes are rare and of questionable accuracy. This is an issue given that the purpose of the long-range transportation planning process is to evaluate the impacts on the future population and future environment, twenty years hence. The metropolitan planner should strive for accurate and reasonable socio-economic forecasts. In addition, the planner should enlist citizen groups who may have access to local data sources, or their own databases and contacts.

**Federal Data Sources**

The U.S. Bureau of the Census is the prime source for small area socio-economic statistics in the nation. Major programs of the Census Bureau relevant to environmental justice include the decennial census, the Current Population Survey (CPS), the Population Projections Program, and the Small Area Income and Poverty Estimates (SAIPE) program.

The term "small area" may be confusing. To a metropolitan transportation planner, a "small area" is most likely a census tract, a neighborhood, or a travel analysis zone (TAZ). To state and federal demographers, "small area" typically means county. So, this paper uses the term "very small area" to refer to data – historical, current estimates, and projections – at the tract, neighborhood or TAZ level.

The decennial census is the best source for base year socio-economic data at the "very small area" level. The other Census programs – the Current Population Survey, the Income and Poverty Estimates Program, and the Population Projection Program, provide current year estimates and projections at a "small area" level, i.e., either state level in the case of the Population Projection Program, or county-level in the case of the Income and Poverty Estimates Program.

*Decennial Census Data*

Data from Census 2000 will be made available in the 2001 to 2003 time period. (In the interim, vintage 1990 Census data can be used for environmental justice analyses.) "Short form" data (questions asked of all Americans) include such items as age, race, and ethnicity, and will be available at the "very small area" level in 2001. "Long form" data (questions asked of 1-in-8 American households) includes such items as ancestry, income, disability, and vehicle availability. "Long form" data will be made available at the "very small area" level beginning early 2002. Data from the Census 2000 short form

will be available down to the census block level; data from the long form, to the "block group" and TAZ level.

An excellent model for preparing a regional demographic profile is the book "The Ethnic Quilt: Population Diversity in Southern California" by the geographers Allen and Turner (10). The authors paint a comprehensive portrait of the ethnic geography of the greater Los Angeles region.  They make extensive use of 1990 Census race, ethnicity, and ancestry data at the very small area level. The analysis is also noteworthy for using 1990 Census Public Use Microdata Sample (PUMS) in describing the detailed occupation and industry characteristics of population by race-ethnicity.

One interesting measure in Allen and Turner is the use of an entropy index to describe the racial/ethnic diversity within neighborhoods. This entropy index ranges from 0.0 (100 percent of population in one racial group) to 1.0 (say, 20 percent population of each: non-hispanic white, non-hispanic african american, non-hispanic asian/pacific islander, non-hispanic American Indian/Native Alaskan, and hispanic). The entropy index is based on White (11) and can be calculated as:

$$Ei = \frac{\sum_{k=1}^{5}[P_{ik} * \log(P_{ik})]}{-1.609}$$

Where:

$E_i$ = Entropy, or Diversity Index, by Neighborhood of Residence (i)

$P_{ik}$ = Proportion of Population in Race (k) by Neighborhood of Residence (i)

-1.609 = constant, based on five racial/ethnic categories.

An example calculation of this diversity index calculation is shown in Table 2. Again, this is useful in showing either increasing or decreasing racial/ethnic diversity levels at the state, metropolitan, community or neighborhood levels.

Examples of maps to include in a regional demographic profile include: minority share of total population (Figure 1); leading racial/ethnic group (Figure 2); and the ethnic diversity

(entropy) index (Figure 3), data for the San Francisco Bay Area based on the 1990 Census.

The metropolitan planner will need to master geographic information systems (GIS) for the detailed mapping of race-ethnicity-ancestry, elderly, disabled, and low-income population using data from the 1990 and 2000 decennial censuses. The regional demographic profile may be a major undertaking for a metropolitan planning organization, and may take the form of an atlas or map-book describing the diversity of the metropolitan area. Few, if any MPOs will have the resources to prepare a profile as extensive and rich as the Allen and Turner monograph. More modest approaches are advised. Still, citizens advisory groups may be highly appreciative of detailed and visual information as can be obtained from the decennial census.

Issues related to the differential under-count in Census 2000 are very relevant to understanding race-ethnicity patterns. Citizen advisory groups should be kept abreast of federal activities with respect to adjustments for the under-count, including court decisions and the decision of the Census Bureau on whether or not to adjust the data. Another issue of potential interest to advisory groups is the treatment of multi-racial statistics in census products.

*Census Estimates and Projections*

The U.S. Census Bureau is required to produce small area income and poverty estimates (SAIPE) in response to the federal Improving America's School Act of 1994. These are model-based estimates of persons in poverty, based in part on data from the annual Current Population Survey (CPS). County-level data is currently available for the years 1989, 1993 and 1995. Data is also published at the school district level (12). It's important to note the statistical uncertainty associated with these persons in poverty estimates. For example, the confidence interval around the 1989 decennial census-derived value is 490 to 514 thousand San Francisco Bay Area residents. This confidence interval ranges from 486 to 711 thousand Bay Area residents in poverty in the year 1995 (Table

1). For purposes of environmental justice analysis, the SAIPE poverty estimates are important indicators for metropolitan areas. It is equally important for planners to convey the statistical uncertainties associated with these estimates, and to note that the Census Bureau does not forecast future poverty levels.

**Table 1**
**San Francisco Bay Area Poverty Estimates, 1989-1995**
**Census Bureau, Small Area Income and Poverty Estimates Program (SAIPE)**

|  | Persons in Poverty | | | Share in Poverty | | |
|---|---|---|---|---|---|---|
|  | 1989 | 1993 | 1995 | 1989 | 1993 | 1995 |
| Low Estimate | 491,000 | 514,000 | 486,000 | 8.3% | 8.2% | 7.6% |
| Central Estimate | 502,000 | 629,000 | 598,000 | 8.5% | 10.1% | 9.4% |
| High Estimate | 514,000 | 744,000 | 711,000 | 8.7% | 11.9% | 11.2% |

The population projections program of the Bureau of the Census is less useful to the metropolitan planner given that population by race-ethnicity and sex forecasts are not produced below statewide levels. The Bureau's documentation is worthwhile reading to understand the complexities associated with population forecasting by race-ethnicity and sex (13). Difficulties and errors associated with fertility, mortality, and migration assumptions at the national and state levels are important to understand if the desire is to appreciate forecasting errors at the very small area level.

**State Data Sources**

The State of California's Demographic Research Unit of the State Department of Finance (California DOF) is responsible for small area (county-level) population estimates and forecasts for statewide planning and budgeting purposes. Two data products of interest to metropolitan planners (in California) are 1990 to 1998 annual estimates of population by race/ethnicity (14), and county-level population projections by race/ethnicity to the year 2040 (15). The estimates program makes use of reported birth, death and school enrollment statistics by race/ethnicity. The projections are based on 1990 Census data, and statewide assumptions about fertility, mortality and migration. Migration is easily the most difficult population component to predict. The State DOF reports that historical

annual migration into California has ranged from –82,000 to +421,000, with future,
short-term migration estimated at +250,000 persons per year.

State DOF race/ethnicity population projections for the San Francisco Bay Area are
presented in Table 2.

**Table 2**
**San Francisco Bay Area Population Projections by Race/Ethnicity, 1990-2030**
**Population in Thousands, Share of Total Population, and Diversity Index**

|                        | 1990   | 2000   | 2010   | 2020   | 2030   |
|------------------------|--------|--------|--------|--------|--------|
| White, not hispanic    | 3,673  | 3,665  | 3,588  | 3,388  | 3,137  |
| Hispanic, any race     | 933    | 1,299  | 1,651  | 2,015  | 2,464  |
| Asian/Pacific Islander | 896    | 1,357  | 1,814  | 2,164  | 2,566  |
| Black/African Amer.    | 519    | 587    | 639    | 692    | 726    |
| Amer. Ind.             | 30     | 31     | 34     | 35     | 35     |
| Total                  | 6,051  | 6,939  | 7,726  | 8,294  | 8,928  |
|                        |        |        |        |        |        |
| % White                | 60.7%  | 52.8%  | 46.4%  | 40.8%  | 35.1%  |
| % Hispanic             | 15.4%  | 18.7%  | 21.4%  | 24.3%  | 27.6%  |
| % Asian                | 14.8%  | 19.6%  | 23.5%  | 26.1%  | 28.7%  |
| % Black                | 8.6%   | 8.5%   | 8.3%   | 8.3%   | 8.1%   |
| % Amer. Ind.           | 0.5%   | 0.4%   | 0.4%   | 0.4%   | 0.4%   |
| Total                  | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
|                        |        |        |        |        |        |
| Diversity              | 0.691  | 0.748  | 0.781  | 0.802  | 0.812  |

*Source: author compilation of data from the California State Department of*
*Finance, Demographic Research Unit.*

Professional demographers are concerned about the quality and nature of population
forecasting by race and ethnicity. Hirschman writes about the uncertainties surrounding
immigration assumptions: "Similar to the problem of local area projections, for which
internal migration is the great unknown, estimates of future levels of international
migration are dependent on unforeseeable economic forces and the very unpredictable
political context that shapes immigration law." ([16](#)). Hirschman also comments on
changing measurement of ethnicity in the decennial censuses, patterns of ethnic
intermarriage, and self-identification uncertainties as other major issues related to
population projections by race and ethnicity ([16](#), [17](#)). Valid criticisms of race/ethnic
population projections are the uncertainties regarding international migration, between
states migration, and residential mobility patterns within a metropolitan area. Most of the

assumptions made at the federal and state level are basically a continuation of past trends, though both federal and state demographers are up front with either a single migration assumption or a range of migration assumptions. It is important to convey the nature of the unease surrounding these assumptions to citizens advisory groups who may be the audience for these projections.

**Local Data Sources**

Local data sources are meant to include the socio-economic databases and forecasting systems in place in many metropolitan planning organizations (MPOs) or councils of governments (COGs). In the nine-county San Francisco Bay Area, the Association of Bay Area Governments (ABAG) is responsible for "very small area" socio-economic and land use forecasts. MTC, the metropolitan planning organization for the Bay Area, also prepares household auto ownership forecasts and travel demand forecasts for use in long-range transportation planning studies. MTC's travel demand forecasts are based on census tract-level socio-economic forecasts prepared by ABAG, and adjusted to fit the MTC's 1,099 regional travel analysis zone system.

The ABAG tract-level projections allocation model is known as the "Subarea Projections Model," or SAM (18). SAM is used to product tract-level projections of total employment by industrial sector, land use by residential and commercial-industrial use, and population characteristics, including: total population, household population, employed residents and total households.

ABAG's SAM system is also used to predict the distribution of households by income level. Current MTC travel demand models require, as input, the distribution of households by income quartile level, as follows: < $25,000; $25,000 to $45,000; $45,000 to $75,000; and > $75,000 (all in 1989 constant dollars). The low-income quartile as defined by ABAG and MTC is not the same as the "low income" definition in environmental justice guidelines. Environmental justice equates "low income" with persons below the poverty level, which requires a three-way classification of households

by age of householder by persons in household by household income level. Though the definition of low income households are different, ABAG/MTC compared to environmental justice guidelines, the ABAG/MTC low income household forecasts may be a very useful surrogate measure to evaluate the future year distribution of either low income or poverty households.

ABAG also maintains a tract-level "accounting model" to estimate the total population by four age groups: ages 0-4, 5-19, 20-44, 45-64, and 65+ ([19](#)). These are basically age-cohort survival models applied at the tract level and adjusted to match county control totals. MTC uses the ABAG age cohort data in predicting the number of school trips, and the age 65+-population data in predicting the share of households with zero workers (i.e., retired households.) ([20](#)).

Neither ABAG nor MTC produce forecasts of population by race/ethnicity or by disabled status. MTC staff did produce a technical summary on the Bay Area disabled population based on the 1990 Census ([21](#)). This descriptive report will be a useful starting point for comparing to Census 2000 results. This author is not aware of any published literature on very small area procedures for projecting disabled population. There are examples of very small area race/ethnicity population forecasting procedures, but these are basically accounting procedures to allocate county-level race/ethnicity forecasts to a fine zone level.

To conclude this section, there are numerous data sources and analysis methods available to metropolitan planners at the federal, state and local levels. The analyst can assemble this information to provide an initial demographic/geographic profile to citizens advisory and other interest groups. Use of geographic information systems (GIS) to map available data is strongly recommended.

As a warning, the metropolitan planner should be careful, if not humble, in acknowledging the limitations of the data – historical data as well as current estimates or future projections. The opposite of humility is hubris. A dictionary definition of "hubris"

is "exaggerated pride or self-confidence often resulting in retribution." Mechanical, computer procedures can always be developed to produce numbers, yet simplified mechanical procedures cannot be used to realistically or accurately assess neighborhood-level population dynamics.

## METHODS FOR ANALYZING TRANSPORTATION PROGRAM EQUITY

The context for this discussion is the transportation equity analysis conducted by MTC for the 1998 update of the Bay Area regional transportation plan. The methodology, analysis and conclusions are included in a staff memorandum (22). The basic purpose of the equity analysis was to evaluate the changes in transit and auto accessibility when comparing the plan alternative to a "do-nothing" alternative. Changes in accessibility were analyzed for "disadvantaged" and "not disadvantaged" neighborhoods, comparing changes in drive alone, carpool, and transit accessibility. The stages of analysis include: a) defining neighborhoods of concern; b) extracting accessibility data from transportation planning databases; and c) conducting statistical, GIS and summary analyses of results.

### Defining Neighborhoods of Concern

The analysis paradigm used in the MTC analysis focuses in on particular neighborhoods to determine accessibility implications of the overall transportation plan for gauging equity impacts. This approach could also be used in evaluating the environmental impacts (air quality, noise quality, other environmental externalities) on different sets of neighborhoods.

Definitions of disadvantaged neighborhoods are derived from the non-profit Northern California Council for the Community (NCCC) in a 1997 report (23). The NCCC identified 38 neighborhoods comprised of 142 census tracts using 1990 Census data, based on median household income, public assistance income, and median gross rent as a percentage of household income. The NCCC methodology flags local neighborhoods that are 80 percent or less than each county's median household income. MTC staff then

identified the 133 regional travel zones (out of 1099 total zones) that correspond to these 142 census tracts. Year 2020 population forecasts indicate that 959 thousand persons will reside in the 133 neighborhoods identified as disadvantaged. This compares to the 6.818 million persons expected to reside in the rest of the Bay Area.

The NCCC methodology is useful for identifying low-income neighborhoods in all counties within a metropolitan area. This approach could be extended to examine minority population neighborhoods, senior population neighborhoods, and disabled population neighborhoods within the metropolitan area. Statistical analysis can be done at a travel analysis zone or census tract level, but it is important to map these neighborhoods to understand the distinctive patterns based on these four characteristics: low-income, minority, elderly and disabled.

Citizens advisory groups can then be enlisted to comment on these defined neighborhoods of concern. The advisory groups may suggest that these areas be expanded or contracted based on their knowledge of the changing socio-economic characteristics of their community and the metropolitan area.

**Accessibility Measures from Transportation Planning Databases**

Metropolitan planning organizations such as MTC maintain large-scale regional travel demand forecasting systems that includes data on zone-to-zone travel times and costs by different travel modes. The issue is how to reduce the volume of data to meaningful measures for each neighborhood in the region. The concern is that MPO staff can be overwhelm folks with way too much information to reasonably comprehend; or the MPO staff can underwhelm folks with too little information on these issues.

Two sets of measures were identified in the 1998 MTC analysis: a) total jobs within 30, 45, 60 and 75 minutes travel time by either drive alone, carpooling, or transit, stratified by zone-of-residence; and b) weighted accessibility, by drive alone, carpooling, and transit, also stratified by zone-of-residence.

The more tractable measure is the number of jobs within "xx" minutes travel time by means of transportation. This total number of jobs value is a surrogate for the potential activities that can be reached from a neighborhood, and is useful as an overall measure of accessibility. Total jobs is a surrogate for activities that may include commuting to work, traveling to shop, traveling to other personal business activities, etc.

Drive alone and carpool speeds are generally faster than door-to-door transit travel times, so the number of jobs accessible by auto modes is significantly greater than for transit. The following table summarizes regional level total jobs accessible, by zone-of-residence, for the year 2020 regional transportation plan:

**Table 3**
**Average Number of Jobs Within 30, 45, 60, or 75 Minutes by Means of Transportation**
**MTC Regional Transportation Plan Analysis, 1998**

|  | Transit | Drive Alone | Carpool |
|---|---|---|---|
| 30 Minutes | 71,700 | 702,400 | 795,500 |
| 45 Minutes | 256,700 | 1,377,900 | 1,689,100 |
| 60 Minutes | 535,200 | 2,240,800 | 2,657,200 |
| 75 Minutes | 884,500 | 3,041,900 | 3,449,400 |

This data on regional-level accessibility, stratified by means of transportation and the four different "isochrons" (lines of equal time) can then be further stratified by "disadvantaged" versus "not disadvantaged" neighborhoods, and by comparing the project alternative to a no-project (or other) alternative.

A paired t-test statistical analysis was conducted on this project vs. no-project comparison to determine if the project alternative provides statistically significantly higher accessibility than the no-project alternative. The results from the 1998 long range plan analysis suggest that the project alternative provides higher accessibility than the no-project alternatives across all modes, all isochron breakdowns, and for both disadvantaged as well as not disadvantaged neighborhoods.

The last statistical test was a "standard error of difference between means" test to determine if disadvantaged neighborhoods have significantly higher, significantly lower, or not significantly different accessibility than not disadvantaged neighborhoods. The results suggest that disadvantaged neighborhoods have significantly greater transit accessibility than not disadvantaged neighborhoods. Conversely, "not disadvantaged" neighborhoods have significantly greater auto accessibility than disadvantaged neighborhoods. The most auto accessible neighborhoods are the areas halfway between the major job centers of San Francisco and Silicon Valley in Santa Clara County. The most transit accessible neighborhoods are centered in San Francisco, Oakland, and Berkeley in the central Bay Area.

An alternative to the "jobs within 'xx' minutes" accessibility measure is a one-number, weighted accessibility index. The advantage of a weighted accessibility variable is that it is sensitive to small changes in travel time, whereas the isochron methodology is sensitive to changes only when an isochron boundary is crossed (e.g., accessibility changes from 32 to 29 minutes.) The disadvantage of a weighted accessibility variable is that it is less tractable and less easy to describe to technical, policy and citizens groups.

Maps showing average jobs within 60 minutes by AM peak period drive alone times and AM peak period transit times are included as Figures 4 and 5. These are based on MTC travel time forecasts for the year 2020.

The weighted accessibility analysis used in the 1998 MTC study is defined as:

$$A_{ik} = \sum_j O_j d_{ijk}^{-b}$$

Where $A_{ik}$ is an accessibility index by zone-of-residence "i" by means of transportation "k"; $O_j$ is total employment at zone-of-destination (non-residence); $d_{ijk}$ is travel time between residence zone "i" and non-residence zone "j" by travel mode "k," and "-b" is a "distance decay" parameter commonly found in spatial interaction models such as the common gravity model. These distance decay parameters are known in travel demand

modeling as "friction factors" (the greater then distance, the less likelihood of traveling that distance.) Other functional forms of friction factors include:

| | |
|---|---|
| Inverse Power Function | FF = 300000/ (Tij)^2.0 |
| Gamma Function | FF = 20000 * Tij * exp(-.14 * Tij) |
| Exponential Function | FF = 250000 * exp(-0.12 * Tij) |
| Modified Exponential Function | FF = 150000 * exp(-57 * ln(Tij/1.11)^2.0) |

The modified exponential equation is the best performing friction factor function for use in a Bay Area work trip distribution, and is the same functional form as developed in Gävle, Sweden and as reported in Kanafani ([24]).

Other options and opportunities for using accessibility measures in environmental justice analysis include: a) provide accessibility indices based on non-work travel; b) provide off-peak accessibility indices; and c) stratify accessibility indices by type of neighborhood: low-income, minority, senior, disabled.

Mapping of these accessibility measures can be very beneficial to the environmental justice analysis by showing accessibility changes between different transportation investment scenarios, or changes in accessibility between base and future years. The statistical analyses are very useful in determining if the accessibility benefits of the plan are shared among all neighborhoods on a proportionate or disproportionate basis.

The limitation to this transportation accessibility analysis is that it is constrained to the transit and highway investments that are included in the long-range plan, and may exclude "non-travel model" investments such as transportation livability and transportation enhancement programs.

**FUTURE DATA**

The discussion on future data – data available over the next year to decade – concerns standard products from Census 2000; the special "journey-to-work" package produced by the Census Bureau; and the American Community Survey.

Census 2000 will provide the most relevant socio-economic data for regional transportation planning over the next several years. Data from the decennial census "short form" will be released in spring and summer 2001. Data from the decennial census "long form" will be released in spring and summer 2002. Short form data will be available down to the census block level; long form data, down to the census block group level. Short form data relevant to environmental justice analyses include race, hispanic status and age. Long form data relevant to environmental justice include income, disability, vehicle availability and ancestry. Data on poverty level is derived from long form data on household income, household size, and age of the head of household.

The Census Transportation Planning Package (CTPP) is a customized set of tabulations for use by local and statewide transportation planners. The CTPP is an AASHTO pooled-fund project with significant input from the USDOT modal administrations, the Bureau of Transportation Statistics, and the user community. Definition of these CTPP tabulations is ongoing, and should be finalized by early 2001. Examples of tables that may be useful in environmental justice analysis includes workers by neighborhood of work by race by hispanic origin by poverty status; workers by neighborhood of work by race by hispanic origin by means of transportation to work; etc.

The most significant data source of the future is the Census Bureau's American Community Survey (ACS)(25). Think of the decennial census as the "snapshot of America" once a decade. Now think of the American Community Survey as a "moving picture of America" over the entire decade. The American Community Survey is intended as the eventual replacement for the traditional once-a-decade "long form" and data will be collected on a continuous basis over the entire decade. The 1999 to 2002

period is a comparison period, where data from the traditional long form can be compared to data from the ACS in 31 selected areas from around the U.S. The full-scale implementation of the ACS will commence in 2003 throughout the U.S. Places and counties of 65,000-plus populations will receive annual profile reports from the Census Bureau (e.g., 2003 profiles will be released summer of 2004.) Data for very small areas will be based on multi-year data, and will be first released in 2008 (e.g., tract-level tabulations based on information collected in the five year period 2003 through 2007.)

The American Community Survey represents a major paradigm shift in terms of how small area socio-economic data will be collected and how the data will be used by local planners and data users. Environmental justice analyses of the future will greatly benefit by using annual updates of aggregate estimates of population characteristics for the disabled and elderly, minority and low-income populations.

**CONCLUSIONS**

The prospects for assembling data relevant for environmental justice analysis at the metropolitan planning level are good. The analyst should be aware of numerous data sources at the federal, state and local level. The analyst should also be aware of the statistical limitations of these data and projections, and wary of simple methods to create twenty-year forecasts of these data items at the very small area level.

Accessibility indicators, extracted from regional transportation planning databases, are offered as one measure of understanding the distribution of benefits associated with a long-range transportation plan. Different measures of accessibility are discussed, including simple measures such as "jobs within 30 minutes transit time" and more complex, weighted measures that take into account small changes in travel time between alternatives.

Future data sources such as the Census 2000 Transportation Planning Package (CTPP) and the American Community Survey (ACS) offer great promise to provide detailed and

current data on the geographic distribution of minority, low-income, elderly and disabled persons. The ACS, in particular, will provide annual updates of this data for places and counties of 65,000-plus persons.

## REFERENCES

1.  Calloway, Cheryl A. and Karen L. Ferguson. "The 'Human Environment' Requirements of the National Environmental Policy Act: Implications for Environmental Justice" In Detroit College of Law Review 1997:4, <http://www.dcl.edu/lawrev/97-4/calloway.htm> Accessed July 14, 2000.

2.  Kennedy, Lori "Environmental Justice and Where It Should Be Addressed in the 21st Century Concerning the Transportation Industry: Historical Perspective and Summary" In "Refocusing Transportation Planning for the 21st Century." Transportation Research Board, National Research Council, Washington, D.C., Conference Proceedings #20, 2000, pp. 113-132.

3. President of the United States. "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations." Executive Order 12898, Washington, D.C., February 1994.

4. "Department of Transportation Order to Address Environmental Justice in Minority Populations and Low-Income Populations" Federal Register, April 15, 1997. <http://www.fhwa.dot.gov/environment/ejustice/dot_ord.htm> Accessed July 14, 2000.

5. "FHWA Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" Directive #6640.23, December 1998. <http://www.fhwa.dot.gov/legsregs/directives/orders/6640_23.htm> Accessed July 14, 2000.

6. Wykle, Kenneth R. and Gordon J. Linton "ACTION: Implementing Title VI Requirements in Metropolitan and Statewide Planning" Joint Memorandum of FHWA and FTA, October 7, 1999. <http://www.fhwa.dot.gov/environment/ejustice/ej-10-7.htm> Accessed July 14, 2000.

7. "FTA Fiscal Year 2000 Apportionments, Allocations and Program Information" Federal Register, October 28, 1999, pp. 58211-58263.

8. "State Transportation Planning; Metropolitan Transportation Planning; Proposed Rule" Federal Register, May 25, 2000, pp. 33922-33958.

9. Burbank, Cynthia J. and Charlotte Adams. "INFORMATION: Status of Environmental Justice Activities" Joint Memorandum of FHWA and FTA, January 7, 2000. <http://www.fhwa.dot.gov/environment/ejustice/ej-1-7.htm> Accessed July 14, 2000.

10. Allen, James P. and Eugene Turner. "The Ethnic Quilt: Population Diversity in Southern California." Center for Geographical Studies, California State University, Northridge, California, 1997.

11. White, Michael J. "Segregation and Diversity Measures in Population Distribution" In "Population Index" 52:2, Summer 1986, pp. 198-221.

12. "Small Area Income and Poverty Estimates: Origin of the Project" <http://www.census.gov/hhes/www/saipe/nontechdoc/origins.html> Accessed July 18, 2000.

13. Hollmann, Frederick W., Tammany J. Mulder and Jeffrey E. Kallan. "Methodology and Assumptions for the Population Projections of the United States: 1999 to 2100" Population Division Working Paper No. 38, Bureau of the Census, January 2000.

14. "Race/Ethnic Population Estimates:  Components of Change for California Counties: April 1990 to July 1998" California Department of Finance, Sacramento, California, May 2000. <http://www.dof.ca.gov/html/Demograp/Race-eth.htm> Accessed July 18, 2000.

15. "County Population Projections with Race/Ethnic Detail Estimated July 1, 1990-1996 and Projections for 1997 through 2040" California Department of Finance, Sacramento, California, December 1998. < http://www.dof.ca.gov/html/Demograp/Proj_race.htm> Accessed July 18, 2000.

16. Hirschman, Charles. "Race and Ethnic Population Projections: A Critical Evaluation of their Content and Meaning" Paper presented at the 13th SUNY-Albany Conference on American Diversity: A Demographic Challenge for the Twenty-First Century, paper revised October 1998. <http://www.csde.washington.edu/> Accessed June 6, 2000.

17. Hirschman, Charles. "The Meaning and Measurement of Race in the U.S. Census: Glimpses into the Future" Paper presented at the Annual Meeting of the American Sociological Association, paper revised September 1999. <http://www.csde.washington.edu/> Accessed June 6, 2000.

18. "Subarea Projections Model (SAM): Allocating Employment and Population, Projecting Household Income, and Land Use Accounting" Association of Bay Area Governments, Oakland, California, Working Paper 93-2, February 1993.

19. Prastacos, Poulicos. "System for Forecasting Sex and Age Characteristics of the Population for the Counties and Census Tracts" Staff Memorandum, Association of Bay Area Governments, Oakland, California, July 8, 1987.

20. Purvis, Charles L. "Travel Demand Models for the San Francisco Bay Area (BAYCAST-90): Technical Summary" Metropolitan Transportation Commission, Oakland, California, June 1997.

21. "Disability, Mobility Limitation, and Self-Care Limitation Status in the San Francisco Bay Area: 1990 Census: Summary Tape File 3A" Working Paper #6, Metropolitan Transportation Commission, Oakland, California, October 1993.

22. Purvis, Charles L. "1998 Regional Transportation Plan: Equity & Accessibility Analysis" Staff Memorandum. Metropolitan Transportation Commission, Oakland, California, June 24, 1998.

23. Northern California Council for the Community. "A Guide to the Bay Area's Most Impoverished Neighborhoods – By County: Bay Area Partnership for Building Healthy and Self-Sufficient Communities for Economic Prosperity." San Francisco, California, 1997.

24. Kanafani, Adib. "Transportation Demand Analysis" McGraw Hill Book Co., New York, NY, 1983, p. 175.

25. Prewitt, Kenneth W. "Prepared Statement, Subcommittee on the Census Hearing" U.S. House of Representatives, Washington, D.C., July 21, 2000. <http://www.house.gov/danmiller/census/testimony/7_21prewitt.html> Accessed July 21, 2000.

Figure 1
Minority Share of Total Population
SF Bay Area, 1990 Census
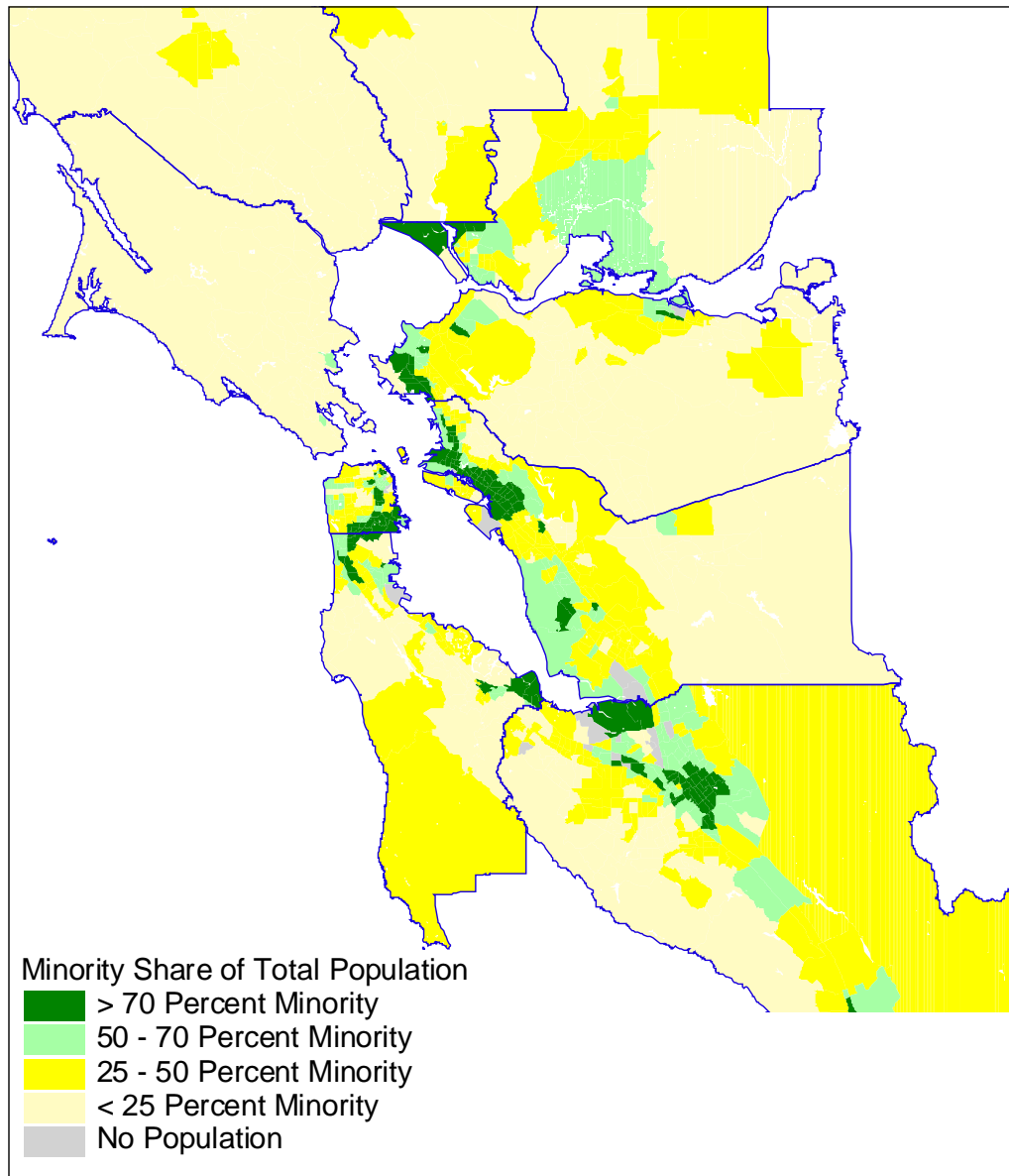


Minority Share of Total Population
- > 70 Percent Minority
- 50 - 70 Percent Minority
- 25 - 50 Percent Minority
- < 25 Percent Minority
- No Population

Figure 2
Leading Racial/Ethnic Group
SF Bay Area, 1990 Census



Leading Racial/Ethnic Group (Plurality)
- Not Populated
- White, Non-Hispanic
- African American
- Hispanic, Any Race
- Asian / Pacific Islander
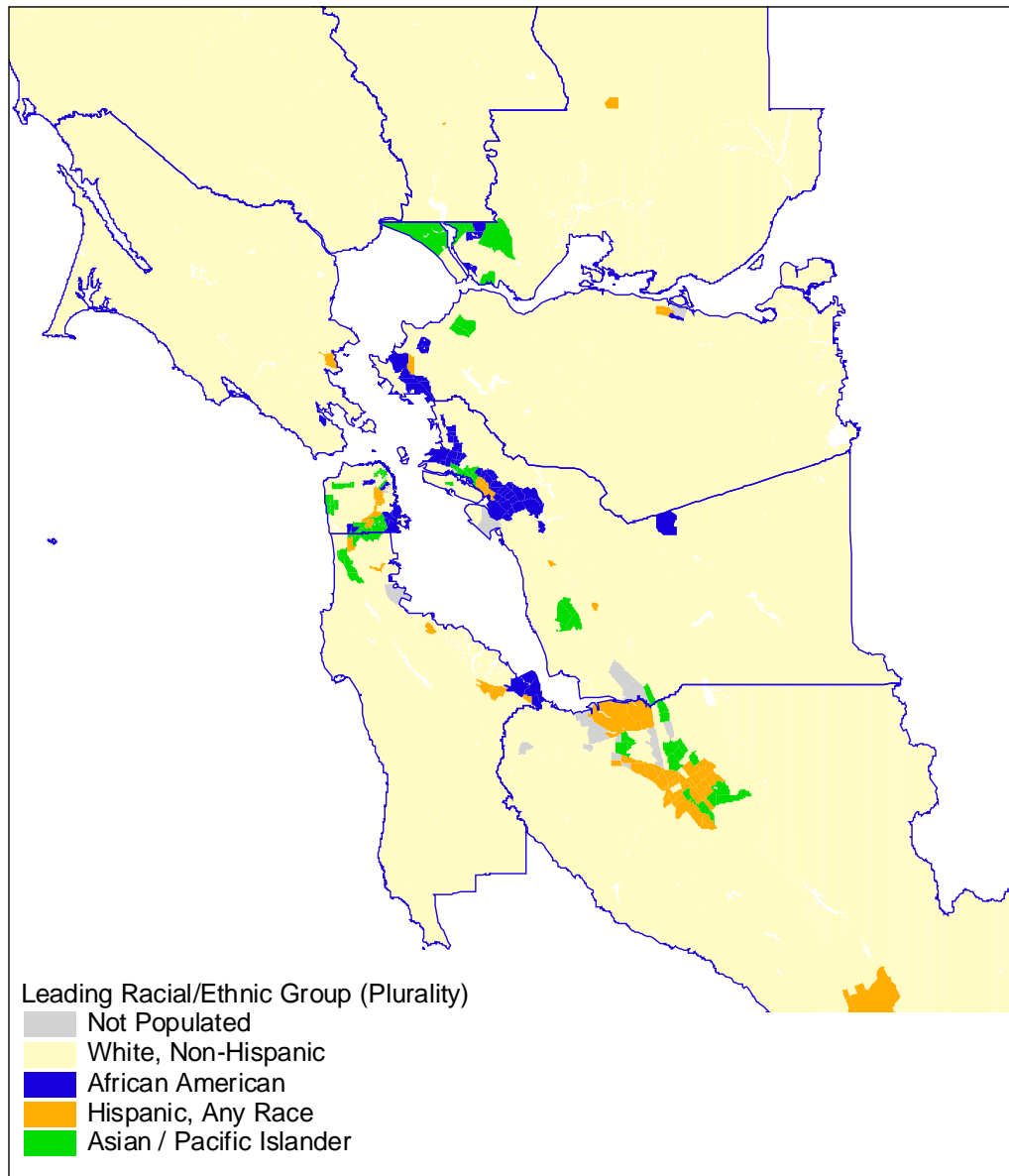
Figure 3
Racial/Ethnic Diversity
SF Bay Area, 1990 Census



Ethnic Diversity Index
< 0.2 (Least Diverse)
0.2 - 0.4
0.4 - 0.5
0.5 - 0.65
0.65 - 1.0 (Most Diverse)
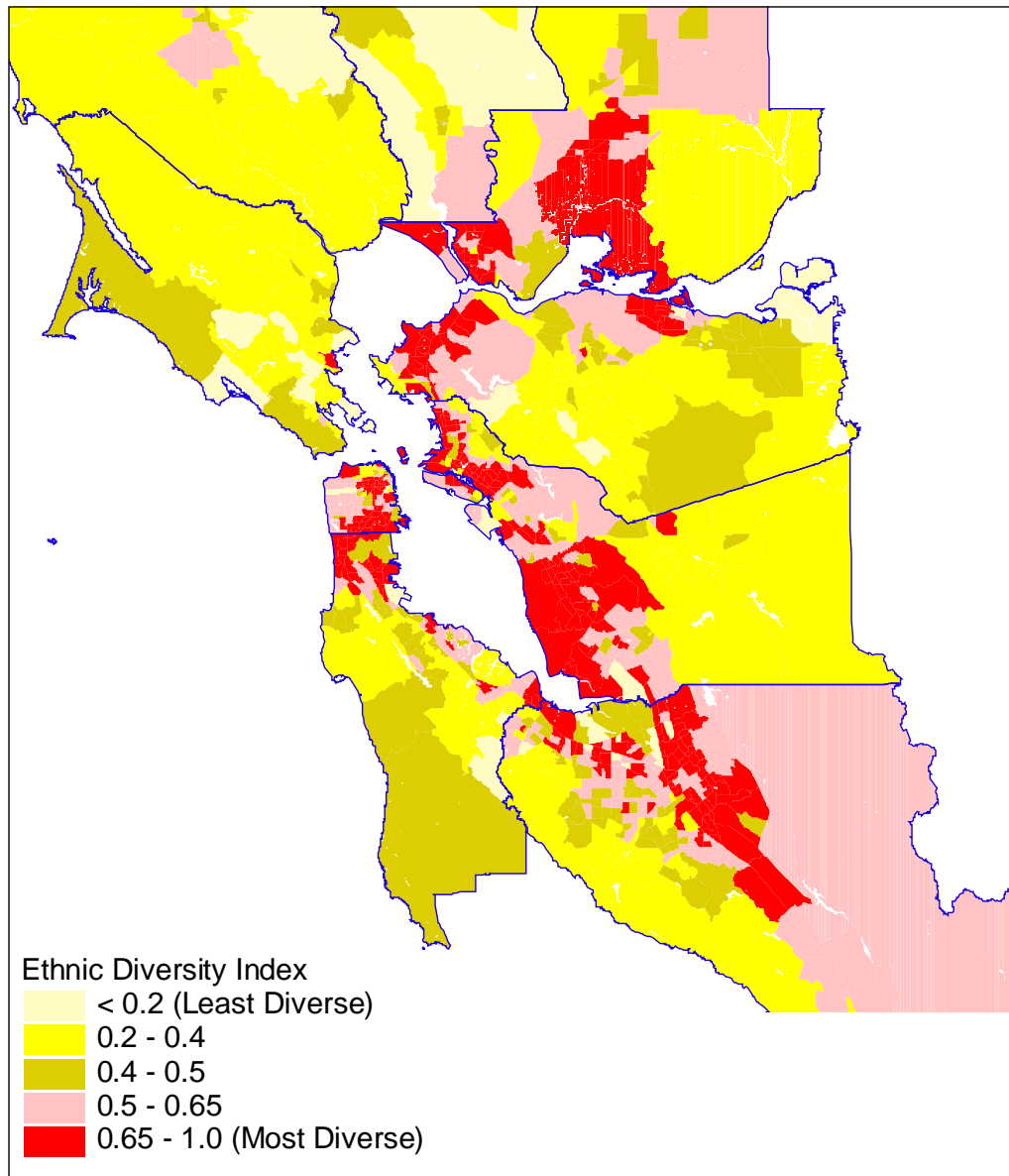
Figure 4
Average Jobs Within 60 Minutes Transit Time
SF Bay Area Regional Transport Plan, Year 2020



Average Jobs Within 60 Minutes Transit Time
- < 200,000
- 200,000 - 500,000
- 500,000 - 750,000
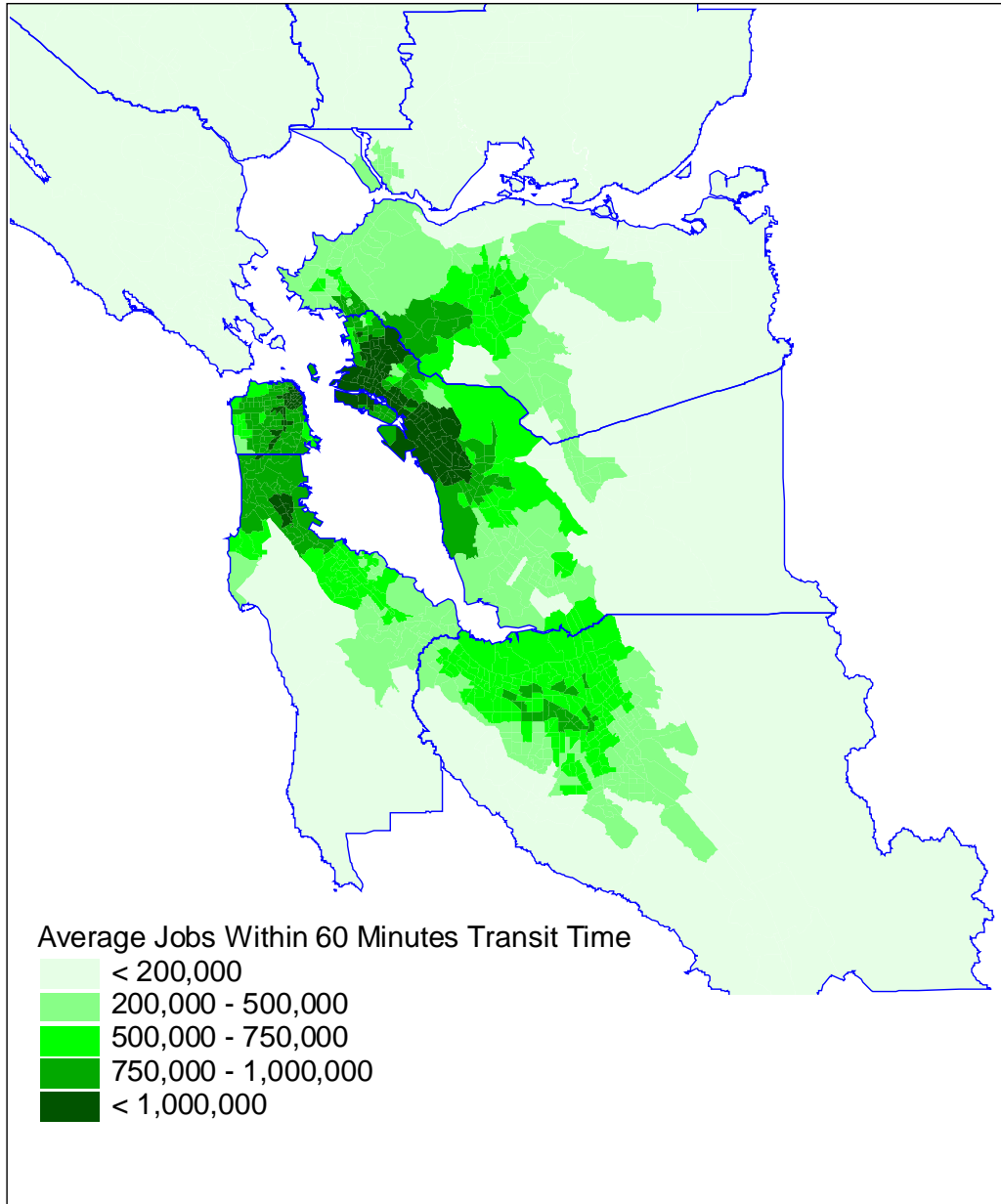- 750,000 - 1,000,000
- < 1,000,000

Figure 5
Average Jobs Within 60 Minutes Drive Time
SF Bay Area Regional Transport Plan, Year 2020